Ferroelectricity Newsletter

A quarterly update on what's happening in the field of ferroelectricity

Volume 8, Number 3 Summer 2000

FeRAMs – STARS OF ISIF 2000

*"*The most exciting topic of basic science and technology reviewed at the ISIF 2000 was that related to FeRAMs, particularly with the demonstration of **"smart cards"** based on FeRAMs. In fact, smart cards were used as the official badges for the conference attendees, and they had the opportunity of testing this new technology by exposing the cards to a reader connected to a computer (contactless reading), observing the information (name, affiliation, etc.) on the screen, and interacting with the computer to correct mistakes and reprogram the card.*"*

This quote is taken from **Orlando Auciello**'s report on the 12th International Symposium on Integrated Ferroelectrics held last March in Aachen, Germany. I think that all of us who attended the conference can attest to the high quality of the presentations. In this issue we have tried to give those colleagues who could not make it to Aachen an overview of what happened there.

Our special thanks go to Orlando Auciello for giving us a detailed account of the most important issues in the various sessions (see pages 2 through 10).

As always, we give you an overview of meetings that might be of interest to you. In September, the **Society of Photo-Optical Instrumentation Engineers** presents a symposium and education program on microelectronic manufacturing in Silicon Valley (see page 29f). On pages 30f and 33, respecetively, you will find details about the **Materials Research Society's 2000 Fall and 2001 Spring meetings**. That brings us to three additional announcements for the next year: The **13th International Symposium on Integrated Ferroelectrics** in March (page 32); the **8th International Conference on Ferroelectric Liquid Crystals** in August (page 34); and the **10th International Meeting on Ferroelectricity** in September (page 35).

Coming back to ISIF 2000, I want to end on a personal note. One of the social programs that surrounded the conference left a particularly strong impression on me. I am referring to the harpsichord recital in the famous Aachen Cathedral, Charlemagne's palatinate chapel. On the inside of the instrument's cover, plainly visible to the audience, were the Latin words "Musica Praeludium Vitae Aeternae," which is, "Music, the prelude to eternal life." I realized how privileged I am to be part of the ferroelectrics community for the simple reason that being alive at a time of such tremendous progress in this field felt like music.

Rudolf Panholzer
Editor-in-Chief

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ISIF 2000 REPORT

REPORT OF ISIF 2000

The science and technology of electroceramic thin films have been two of the fastest evolving interdisciplinary fields of research worldwide during the last eleven years. A major driving force for the extensive research performed during the past ten years in many universities, industrial and national laboratories around the world has been the promise of a variety of applications in a whole new generation of advanced microdevices that may revolutionize various technologies and create new multibillion dollar markets. Properties of electroceramic thin films that have been and are being currently intensively investigated include electrical conductivity, large dielectric permittivity, ferroelectricity, piezoelectricity, pyroelectricity, and electrooptic activity. Perhaps the most publicized application of electrical conductivity of electroceramics has been that related to the new oxide high temperature superconducting (HTSC) materials discovered in the late 1980s, which has been extensively discussed in numerous national and international conferences and in the scientific literature. Although less glamorously publicized than HTSC materials, research on ferroelectrics has expanded approximately the same period of ten years since the late 1980s. However, the main difference today is that we have witnessing the introduction of the first ferroelectric and high dielectric constant thin film-based mass consumption products into the market in the form of "smart cards" based on nonvolatile ferroelectric random access memories (FeRAMs) and cellular phones with high dielectric constant capacitors, respectively, while HTSC-based devices are still a promise for the future. The ISIF 2000 provided a very appropriate forum for reviewing the progress made in the field of integrated ferroelectrics.

The most exciting topic of basic science and technology reviewed at the ISIF2000 was that related to FeRAMs, particularly with the demonstration of "smart cards" based on FeRAMs. In fact, smart cards were used as the official badges for the conference attendees, and they had the opportunity of testing this new technology by exposing the cards to a reader connected to a computer (contactless reading), observing the information (name, affiliation, etc.) on the screen, and interacting with the computer to correct mistakes and reprogram the card.

Other important topics reviewed at the ISIF 2000 included: a) the science and application of ferroelectric materials in high dielectric constant capacitors, which opens new possibilities for manufacturing planar very high-density DRAM memories; b) investigation of piezoelectricity and its exploitation in micromachines such as accelerometers, displacement transducers, and actuators such as those required for inkjet printers, for video-recording head positioning and for micromachining; c) science of pyroelectricity for utilization in the fabrication of high sensitivity room temperature infrared detectors; c) studies of electrooptic activity that can be used in color filter devices, displays, image storage systems, electrooptic waveguides, and optical switches for integrated optical systems. The applications of electroceramic thin films mentioned above are only a part of a more extensive list, which indicates the relevance of these materials in the new technological era of modem society. Substantial progress has been made in the field of synthesis and processing of electroceramic thin films and implementation into prototype devices. However, there are still some critical materials and device issues that need to be solved for the realization of many commercial devices.

Several plenary talks provided an overview of important topics. A plenary talk on FeRAMs revealed that the integration of ferroelectric capacitors with CMOS devices is overcoming major technological challenges such as development of appropriate diffusion barriers for stacking the capacitor directly on top of the drain of the transistor in the 1T/1C architecture. Another plenary talk on FeRAMs was focused on a discussion of the technological challenges related to devices with 0.8 to 0.5 design rules. The speaker in the second plenary talk stated that imprint and endurance are still key issues to be addressed in research on FeRAMs. A plenary talk was given on the status of research on piezoelectric thin films and applications to actuators and sensors in microelectromechanical systems (MEMS). PZT and AlN were reviewed as two important materials for MEMS devices. It was also stated that electrode layers and diffusion barriers play critical roles in the integration of piezoelectric thin films with Si for fabrication of MEMS devices.

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Laminated piezoelectric cantilevers and membranes are being exploited for the fabrication of AFM cantilevers, gyros, ultrasonic transducers, and micromotors, among many other MEMS devices. The speaker indicated that high force MEMS devices require relatively thick piezoelectric films. The issue of endurance needs to be addressed, although it is not as critical as in the case of FeRAMs. A plenary talk was focused on the new science of polarization dynamics at the nanoscale. The dynamics of domain walls was investigated using friction force microscopy, dynamic force microscopy, and voltage modulated scanning force microscopy. This topic is critical because is directly relevant to understanding polarization dynamic at the nanoscale for the next generation of nanoscale ferroelectric capacitors which will be necessary for high density FeRAMs. Finally, the last plenary talk was focused on the topic of high-*K* gate oxide thin films for the new generation of CMOS transistors. An intense research activity is underway at universities, national laboratories and industry to develop a high-k dielectric technology for gate oxides. Two main approaches are being investigated, namely: a) amorphous intermediate-K oxides such as Ta_2O_5 and b) epitaxial high-K oxides such as $SrTiO_3$ and $Ba_xSr_{1-x}TiO_3$. Highlights of the papers presented at the ISIF 2000 are presented below in chronological order of presentation at the conference .

Monday, 12 March 2000

Novel Characterization

This session featured invited and contributed papers on studies of ferroelectric film growth, interface process, and device-related phenomena using a variety of complementary in situ and ex situ characterization techniques. An invited paper in this session addressed studies of ferroelectric thin films growth and interface processes using a novel time-of-flight ion scattering and recoil spectroscopy (TOF-ISARS) technique capable of providing unique insights into film growth and interface processes. This paper discussed recent work using TOF-ISARS which revealed atomic scale information on the better resistance to oxidation, up to 600 ˚C, of TiAlN with respect to TiN. In addition, this work revealed that a new Ti-Al alloy layer exhibits dual excellent diffusion barrier and bottom electrode functionality when featuring an amorphous microstructure. Work on positron annihilation spectroscopy was presented, which provided new evidence for the effect of oxygen vacancies on imprint. It was demonstrated that positron annihilation spectroscopy is a valuable in situ characterization method that can probe the presence of oxygen vacancies in ferroelectric thin films.

Real time studies of the dynamics of ferroelectric domains in lithium tantalate, using novel far and near-field optical methods, were discussed in a contributed paper. This work revealed that 180 ˚ domain wall have strains of up to 10^{-4} extending over several microns adjacent to the walls. In addition, this real-time analysis revealed that the domain walls exhibit reversible motion at electric fields one order of magnitude lower than the coercive fields. New insights into polarization dynamics, obtained by using scanning force piezoresponse imaging, were discussed in the novel characterization session also. This work revealed the formation of a two dimensional network of 90 ˚ domains in PZT films on LSCO electrode layers. It was demonstrated that the 90 ˚ domain walls induce the nucleation of ferroelectric domains that subsequently propagate very rapidly until they produce a complete polarization reversal in the field-excited area.

Piezoelectric Devices

The session started with the presentation of an invited paper that reviewed the development of several MEMS devices for smart physical sensing, minimally invasive surgery, robotics, and bioanalytical medicine. The paper described the materials science and integration strategies to fabricate microsensors (for detection of forces, pressure, and acoustic energy), microvalves, micropumps, and capillaries (for microfluidics MEMS), biosensors, micromotors, and surgical and scientific microinstruments.

A contributed paper described a new PZT piezoelectric cantilever for a high-speed atomic force microscope. The work discussed included investigation of the electrode/PZT integration strategies, particularly the effect of the top

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electrode layer on the cantilever performance. It was demonstrated that RuO_2 electrodes provided the best performance.

Another contributed paper was presented in which the main topic discussed was the synthesis of lead-scandium-tantalate piezoelectric films at temperatures as low as 650 ˚C. The piezoelectric and pyroelectric figure of merits were measured between –20 and 90 ˚C substrate temperature.

The mechanical and electrical fatigue properties of PZT (33/47) films were discussed in a contributed paper. No significant changes in these properties were found up to about 10^5 polarization switching cycles. However, a strong decrease in the value of the d_{31} piezoelectric modulus was observed after 10^5 cycles. This reduction was attributed not to depolarization but to mechanical cyclic load.

FeRAMs

Studies of electrical properties of MOCVD Ir/Ca-doped PZT/Ir capacitors were presented in a contributed paper. It was shown that Ir electrodes may be an alternative electrode material for PZT-based capacitors for FeRAMs.

A second invited paper was focused on a review of the fabrication and performance of PZT-based capacitors with $SruO_3$ (SRO) electrodes.

The dependence of polarization on the orientation of $SrBi_2Ta_2O_9$ (SBT) thin films was discussed for SBT films grown on (100) and (111) $SrTiO_3$ (STO) conductive substrates. This paper showed, as expected from prior theoretical work, that SBT films grown on (100) STO susbtrates have the c-axis oriented perpendicular to the surface of the substrate and exhibit zero polarization, while films grown on the (111) STO substrates, for which the polarization vector lies along the direction perpendicular to the substrate surface, exhibit the highest polarization (16 $\mu C/cm^2$) demonstrated today for SBT-based capacitors.

The electrical properties of $SrRuO_3$/PZT/$SrRuO_3$ capacitors were reviewed in an invited paper. It was demonstrated that these capacitors exhibit improved switching charge, polarization saturation, and fatigue resistance compared with PZT-based capacitors without SRO electrodes.

Results from measurements of the relaxation mechanism in PZT and SBT thin films were presented in a contribute paper. The studies involved procedures based on conventional polarization hysteresis and fast pulse measurements to investigate the fast read and write access of a FeRAM in a nanosecond time interval.

Work on the fabrication of low voltage (3 V) PZT-based capacitors was discussed in a contributed paper. It was demonstrated that secondary phases in the PZT layer resulted in substantial degradation of the electrical properties of the capacitors. The secondary phases were eliminated by using a two step annealing process.

Chemical Deposition

This session started with the presentation of an invited paper focused on a review of chemical solution routes for the synthesis of ferroelectric thin films. It was clear from this presentation that in spite of the many years of research on chemical solution synthesis of ferroelectric films it is still not known how changes in properties such as chemical homogeneity from molecule to molecule, precursor size, reactivity, and molecular weight impact the crystallization behavior and electrical properties of the ferroelectric films. Results from analytical investigations together with insights into precursor properties were discussed in the context of the development of more robust chemical solution routes for the synthesis of ferroelectric films.

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A new low temperature (650 ˚C) chemical solution deposition process was presented for the synthesis for SBT thin films. The process involves the optimization of several parameters (i.e., film stoichiometry and thickness, anneal ambient and temperature ramp rate, UV light processing energy, and precursor solvent) to suppress the fluorite undesirable second phase generally seen when trying to produced SBT films at low processing temperatures. The SBT films produced using the new processing route exhibit excellent electrical properties for FeRAMs.

Pyrolectric and Optical Applications

An invited paper was presented on the latest development in the bulk and thin film technology of $LiNbO_3$, $BaTiO_3$, and $KNbO_3$ materials for electrooptic devices.

The description of a new dielectric bolometer based on BST thin films prepared by the chemical solution route was presented in a contributed paper. The bolometer features a stress-balanced structure achieved via a multilayered membrane scheme that avoids the formation of cracks and deformation characteristic of prior processes. The bolometer exhibits good pyroelectric properties suitable for application in uncooled infrared detectors.

Tuesday, 14 March 2000

Modeling and Theory

A theory on the behavior of ferroelectric materials with composition close to the morphotropic phase boundary was discussed in an invited paper. The excellent physical properties of sensors and actuators fabricated with ferroelectric materials with morphotropic phase boundary composition are attributed to the soft dielectric and electrical properties of the materials with these compositions.

A Landau-Ginsburg-Devonshire-type thermodynamic theory was presented to account for dense laminar domain structures in epitaxial $BaTiO_3$ and $PbTiO_3$ thin films. Calculations were performed to understand the distribution of lattice strains, internal stresses, and spontaneous polarization in polydomain films (with domain walls much smaller than the film thickness). The calculations showed that reversible translational displacements of domain walls from their equilibrium positions may be induced by the applied electric field, creating an additional extrinsic contribution to the permittivity of the ferroelectric layer.

A contributed paper was presented on the calculation of Schottky barrier heights and band offsets of various high-K dielectric materials. The calculations indicated that the Schottky barrier pinning factor S is of the order of 0.28 for $SrTiO_3$, so the barrier depends weakly on the metal work function, which is in agreement with experiments.

Chemical Deposition

A contributed paper was presented which was focused on discussing modeling of transport and growth phenomena in a shower head-based MOCVD reactor for the synthesis of oxide thin films. The model is based on numerical solutions of coupled nonlinear partial differential equations describing the conservation of mass, momentum, energy, and chemical species.

The MOCVD growth of SBT thin films, using alkoxide-based precursors and a novel precursor delivery system based on a pressurized injector, was discussed in a contributed paper.

Testing and Characterization

The session started with an invited paper focused on a discussion of the influence of experimental procedures on reliability issues of ferroelectric thin films for memory applications. Both PZT and SBT-based capacitors were characterized for dimensions and frequencies close to those used in FeRAMs. It was shown that the excitation signal and frequency influence the extrapolated values of device lifetime. It was also demonstrated that measure-

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ments of the quasi-static polarization hysteresis provide information on the type of failure mode dominating in an NVFRAM device.

An empirical reliability model, based on temperature and stress accelerating factors, to predict the switching behavior of FeRAMs up to 10^{15} cycles, was discussed in a contributed presentation. It was demonstrated that temperature is a weak accelerating factor for fatigue, while fatigue lifetime predictions are better modeled using the well-known Eyring model.

A drain current data capture system for metal-ferroelectric-semiconductor field-effect transistors (MFSFET) was discussed in a contributed paper. The system consists of a voltage pulse generator interface bus controller, dual power supplies, a custom MFSFET evaluation circuit, and several custom software modules. Software was developed to collect drain current from all MFSFETs simultaneously.

This session finished with an invited paper focused on the discussion of the status of knowledge on polarization fatigue. The data presented indicate that there are still some issues to be resolved in relation to how the oxygen vacancies localization affect the fatigue process.

Nano-size Effects

A contributed paper was presented with a discussion of patterning and testing of sub-100 nm capacitors. The patterning was produced using a new generation of electron beam direct writing system. Switching of 100 nm PZT-based capacitors was achieved as indicated by measurements of the piezoelectric response using an AFM-based piezoresponse imaging technique.

A new method for producing sputter-deposited PZT thin films with large grains (~ 40 μm long) was discussed in an invited presentation. Crystallized PZT dots were used a seeds for growing grains laterally to form a square pattern on a Pt electroded substrate. The electrical characteristic of these large grain PZT-based capacitors were superior to those of polycrystalline PZT-based capacitors.

Physical Deposition

This session started with an invited paper reviewing the status of pulsed laser ablation deposition of ferroelectric and antiferroelectric thin films. Particular emphasis was given to a discussion of the synthesis of $SrBi_2Nb_2O_9$, $SrBi_2Ta_2O_9$, and $SrBi_2(Nb,Ta)_2O_9$, PZT and $PbZrO_3$.

The effect of crystallographic orientation of SBT thin films on the polarization properties were discussed in a contributed paper in relation to the synthesis of these films using PLD. Films consisted of region with single orientation and others with mixed (110), (100), and (001) orientation. The regions with mixed orientation featured rectangular as well as equiaxed grains protruding out of a smooth c-oriented background. Regions with mixed orientation exhibited good hysteresis loops, while c-axis oriented regions did not show polarization. Nanoscale probes were used to switch nano-regions to investigate the switching behavior of nanoscale capacitors.

The properties of reactively sputtered IrO_x electrode layers, for use in PZT-based capacitors, were discussed in a contributed paper. Changes in the IrO_x film properties were quantified using a combination of x-ray diffraction, sheet resistance, and stress, which showed that the crystalline structure of the IrO_x layer affects the switching properties of the capacitors.

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DRAM

This session started with an invited paper on prospects for high permittivity dielectrics for high density DRAMs. Alternative schemes for these devices include MIS and MIM TaO_x, or amorphous TaO_x / Pt, RuO_x, or Ru heterostructure electrodes. Amorphous TaO_x exhibit a permittivity of about 25, while crystalline Ta_xO_5 on Pt or RuO_x exhibits a permittivity ~ 40.

The effect of the thickness of Pt bottom electrode layers in cup-type BST capacitors on their electrical properties was investigated for bottom electrode thickness of up to 15 nm. For cup-type capacitors, the thickness of the bottom electrode should be as small as possible. It was determined that the electrical properties of the BST capacitors did not degrade substantially down to 15 nm bottom Pt electrode layers.

The fundamental understanding of materials issues in ferroelectric thin films were discussed in a contributed paper. It was shown that for PLD-deposited $SrTiO_3$ films that exhibit some strain, the cubic-to-tetragonal transition temperature is about 800 ˚K, as compared with the 105 K transition of single crystals. In films with little strain the transition is about 125 K, i.e., closer to that of a single crystal. It was also shown that the temperature dependence of the low-frequency complex dielectric constant exhibits a markedly different behavior with respect to that of a single crystal.

The session concluded with an invited paper focused on a discussion of the microstructure-property relationship of BST-based capacitors for DRAMs and high frequency devices. Magnetron sputter-deposited BST films can provide capacitors with high tunability (3-4:1) and low losses (~0.0037, one of the lowest demonstrated for sputter-deposited BST films). MOCVD produced BST films that integrated with Pt electrodes resulted in capacitors with excellent properties for DRAMs.

Wednesday, 15 March 2000

Circuits and Devices

A comparison between standard and chain-type FeRAMs architectures was presented in a contributed paper. It was shown that the chain-type architecture exhibits superior performance over that of the conventional 1T/1C architecture. The use of the Preisach theory of hysteresis provided device performance results that compared well with experiments.

An invited paper was presented on the status of integration of passive components in thin film based devices. There is a drive for producing coupling capacitors, resistors and inductors using integrated thin film components on the IC boards. The trend for integration is similar to that for the semiconductor industry.

This session finished with an invited paper focused on a discussion of the trend in the development of the chain-type architecture for FeRAMs. This configuration enables: a) a small memory cell ($4f^2$), which covers half the area of the conventional cell, and b) access and cycle time as fast as that of DRAMs. Prototype chain-type FeRAMs have been demonstrated for megabit-scale memories. Random access times of ~37 ns and read/write cycles of ~ 80 ns at 3.3 V have been demonstrated.

DRAM

The session started with an invited paper on the status of research on the ferroelectric properties of epitaxial $BaTiO_3$ thin films on Si substrates. $BaTiO_3$ thin films were prepared on $SrRuO_3$/Pt/TiAlN/Si substrates. The BST films grow with the c-axis normal to the substrate surface. No polarization fatigue were observed for capacitors excited with 3 V up to 10^{11} switching cycles.

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Segregation phenomena in thin films of $BaTiO_3$ exposed to 600 ˚C processing temperature were studied using AFM, SIMS, and XPS analysis. These studies revealed substantial changes in the surface morphology and in-depth elemental distribution suggesting that chemical restructuring occur in these films, comparable to similar effects observed in crystalline material.

The session concluded with an invited paper discussing the stacked-capacitor scheme for DRAMs. The properties of the capacitors depend strongly on the deposition method and conditions, the electrode layer and the electrode/BST interface conditions. The mechanism influencing the capacitance and charge degradation as well as the influence of forming gas annealing on the electrical properties of the capacitors were discussed in detail.

Integration

The status of research on high-K oxide thin films for field effect transistors with epitaxial $SrTiO_3$ gate dielectric on Si. The capacitance of 110 Å dielectric films is electrically equivalent to less than 10 Å of SiO_2. The interface trap density of states between the $SrTiO_3$ and the Si substrate is about 6.4×10^{10} states/cm^2 eV, while the inversion layer mobility is 221 cm^2/Vs and 62 cm^2/Vs for n-channel and p-channel devices, respectively. The gate leakage in these devices is ~ 2 orders of magnitude smaller than for a similar SiO_2 gate.

A new damascene approach for patterning Pt, Ir, and IrO_2 was described in a contributed paper. Chemical mechanical polishing (CMP) involving new slurries with standard abrasives and oxidizers were used for the CMP process. The TEOS erosion was about 20-40 nm providing good selectivity between the TEOS and IrO_2. The polished surface of the Ir, IrO_2 and TEOS exhibited a roughness of about 0.2-5 nm. The results discussed in this paper indicate that the damascene process described here is compatible with an industrial environment.

The fabrication of double metal FeRAMs without degradation of remanent polarization, using an Ir/IrO_2 barrier layer between the top Pt electrode of the capacitor and the Al metallization, was discussed in a contributed paper. It was demonstrated that Ir/IrO_2 layer works much better than TiN as a barrier to inhibit the reaction of Pt and Al, while exhibiting a contact resistant close to that of TiN. The Ir/IrO_2 barrier may be applicable for integration to both PZT and SBT-based capacitors.

Field Effect Devices

The session started with an invited paper discussing theoretical and experimental work to develop an all-oxide nanoscale FET device. It was shown that p-type devices with YBCO channels and $SrTiO_3$ gates have been fabricated with channel lengths of 5-10 microns, on/of ratios of up to 10,000 and currents up to 0.7 mA. Computer simulations predict that adequate on/of ratios and currents can be obtained for a 10 nm channel length device.

A novel approach to control ferroelectric polarization direction by shaping the perovskite ferroelectric film grown on Si was discussed in a contributed paper. For perovskites grown directly on Si substrates, the differential thermal expansion between film and substrate induce a biaxial stress in the plane of film such that the polarization axis lies in the plane. This polarization direction is not suitable for affecting the surface potential of the Si interface as required for FFET-based memories. A solution to this problem was provided by shaping the ferroelectric film into a mesa structure, which helps turn the polarization direction along the axis normal to the substrate surface.

A read-disturb-free ferroelectric gate FET memory was described in a contributed paper. In this scheme, the increase in the channel current of the transistor in the off state, produced by the repetitive applications of the read bias in the conventional approach, is suppressed by making the surface potential to take a flat-band structure, such that the memory window depends on the surface potential difference between the flat-band state (off-state) and the depletion state (on-state) under the gate.

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The physics of epitaxial oxide templates on Si was discussed in a contributed paper focused on describing a method of producing stable templates for growing high-K thin films on Si. This work demonstrated that a few unit cells of $SrTiO_3$ acts as a robust substrate enabling transfer through air and overgrowth of further epitaxial high-K films.

High Frequency Devices

Ferroelectric tunable coplanar waveguide and conductor based coplanar waveguide components for Ku and K-band applications were discussed in a contributed paper. The main objective of the work discussed in this paper was to study the effect of inserting a ferroelectric tuning layer in coplanar waveguide (CPW) and conductor-backed CPW (CBCPW) components using theoretical modeling and experimental verification.

The current status of BST thin films integration into tunable microwave components was discussed in an invited paper. The fabrication and characterization of phase shifters for phase array antennas and tunable filters from various groups were discussed.

A second invited paper was presented focusing on recent advances on the synthesis and characterization of BST films and their integration into phase sifters. BST films produced by magnetron sputtering by the group presenting this paper exhibit very high tunability (4:1) and one of the lowest losses (~0.003) demonstrated today for sputter-deposited films. These films were used to produce high performance phase shifters featuring monolithic integrated BST capacitors in transmission lines.

The influence of strain on the microwave dielectric properties of BST films were discussed in another invited paper in this session. BST films grown by PLD on MgO and $LaAlO_3$ substrates exhibit a tetragonal distorted structure due mainly to lattice mismatch between the film and the substrate. X-ray analysis showed oxygen vacancies at the film-substrate interface that lead to enlarged film lattice with respect to the substrate. The number of oxygen vacancies is reduced by oxygen annealing of the films, although this does not result in strain reduction. The work discussed in this paper indicates that BST films with low stress are required to produce capacitors with high tunability and low losses. Studies with similar results as those described above were described in another contributed paper by an independent group, which also demonstrated that film strain play a critical role in defining the high frequency properties of the BST-based capacitors.

The effect of electrode materials on GHz ZnO film bulk-acoustic-wave resonator was discussed in a contributed paper. ZnO films grown on Au exhibit an abrupt interface, while ZnO films grown on Al show amorphous interface layer. The ZnO/electrode interface plays a critical role in controlling the high frequency properties of the devices based on these films.

Integration

Electrode and barrier materials issues related to stacked capacitors for ferroelectric memories were reviewed in an invited paper that opened this session. For SBT-based capacitors, the high processing temperature required to achieve good electrical properties places stringent constrains on the diffusion barriers, while these constrains appear to be less stringent for the case of PZT-based capacitors.

The mechanisms underlying the plasma etching processes in reactive ion etching for capacitor patterning were discussed in a contributed paper. PZT can be appropriately etched with
CCl_4/CF_4+Ar plasmas. Etching of RuO2 can be accomplished with O_2, CF_4 and SF_6 plasmas.

Cross-contamination processes during the fabrication of PZT-based FeRAMs were discussed in a contributed paper. It has been determined that Pb, Zr, and Ti contaminants can be transferred, through tools previously exposed to PZT, on

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to wafers, with concentrations up to $\sim 10^{10}$ cm^{-2}, while Ir contaminant is transferred only with concentrations up to 10^{9} cm^{-2}. In any case all these contaminants can be eliminated with conventional surface cleaning processes.

Studies of hydrogen degradation of ferroelectric capacitors were presented in contributed papers. In two independent studies, it was shown that hydrogen interaction with SBT layers leads to Bi depletion and creation of associated oxygen vacancies, resulting is severe polarization reduction. In one of the studies, detailed cross-section TEM analysis revealed that hydrogen interaction with SBT results in depletion of Bi from a near surface region about 30 nm deep and strong accumulation of Bi at grain boundaries, which can account for the nearly 10 order of magnitude increase in leakage current of SBT capacitors exposed to hydrogen processes. Oxygen recovery anneal results in partial recovery of Bi in the depleted region, and partial reduction in leakage. Further work is urgently needed to understand and control the hydrogen-based degradation processes.

The optimization of the Pt/SBT/CeO_2/ Si(001) gate stack for low voltage ferroelectric field effect transistor was discussed in a contributed paper. It was found the leakage current across SBT capacitors increased with Ce content in the diffusion barrier, while the polarization decreased from 20 $\mu C/cm^2$ for pure SBTR capacitors to about 13 $\mu C/cm^2$ for SBT layers purposely contaminated with Ce.

Poster Session

A new IR nonlinear optical material ($CsGeCl_3$) with high NLO coefficient and damage threshold was described in a poster.

The benefits of using conducting oxide electrodes for pyroelectric devices were discussed in a poster focused on the investigation of LSCO electrodes for pyroelectric devices.
Micromachined 4 x 4 pyroelectric sensor array using PMN-PT were described in a poster in which it was demonstrated that these films should be considered as good alternatives for this application.
A poster on the piezoelectric properties of Nb-doped PZT showed that 1-2% Nb doping results in the optimization of the d_{33} coefficient.

The effect of domain structure, 90 ˚ rotation and 180 ˚ switching processes on the dielectric properties of polycrystalline PZT films was discussed in view of the relevance of electrochemical effects in ferroelectric films.
Detailed studies of H-induced degradation of SBT films were presented, showing the power of combined in situ ion bean analysis and ex situ cross section TEM to understand the degradation mechanisms.
AFM Piezoresponse imaging provided new insights into the effect of electrode edges on the fatigue properties of PZT capacitors. Fatigue was preferentially induced first on the edges of the electrodes, while it was delayed by one to two cycle-decades at the center of the electrodes.

Work on imaging of ferroelectric domains using the AFM piezoresponse imaging was reported in several posters.
A new mechanism to account for superfast switching was proposed on the bases of studies of domain kinetics by in situ visualization of instantaneous domain patterns using SEM and SFM methods.

The synthesis of various ferroelectric thin films by MOCVD, sputter-deposition, PLD, and sol-gel, including PZT and SBT, and characterization of their ferroelectric properties were described in several posters.

Several posters presented work directed at developing low temperature processing of SBT thin films with the main objective of reducing the thermal budget for fabrication of FeRAMs.

— Orlando Auciello
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ISIF 2000 PAPERS

12TH INTERNATIONAL SYMPOSIUM ON INTEGRATED FERROELECTRICS (ISIF 2000)

The following is a list of titles and authors of oral and poster contributions given at the 12th International Symposium on Integrated Ferroelectrics, held 12-15 March 2000 in Aachen, Germany.

OralContributions

PLENARIES

FeRAM 2000: Where is this technology today?
C. Mazuré

FeRAM integration technology, today and tomorrow
T. Otsuki, T. Sumi, E. Fujii, Y. Shimada, Y. Judai, Y. Sasai, K. Sato, L.D. McMillan, and C.A. Paz de Araujo

Nanoaspects and experiments of ferroelectric domains and domain walls
L. Eng

Piezoelectric thin films: From smart materials to smart applications
P. Muralt

Development of new high K dielectrics for silicon logic devices: An urgent requirement and major challenge
Angus I. Kingon and Jon-Paul Maria

NOVEL CHARACTERIZATION

Image production mechanism for scanning nonlinear dielectricmicroscopy with super high resolution and its application to quantitative evaluation of linear and nonlinear dielectric properties of ferroelectric materials
Y. Cho, K. Ohara, S. Kazuta, and H. Odagawa

Characterization of domain structures in epitaxial PZT thin films using synchrotron XRD effects of elastic strain relaxation
K.S. Lee and S. Baik

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Ferroelectric $Pb_5Ge_3O_{11}$ MFMOS capacitor for one transistor memory application
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Buffer layer dependence of memory effects for $SrBi_3Ta_2O_9$ memory capacitors on Si
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The influence of strain on the microwave dielectric properties of $(Ba,Sr)TiO_3$ thin films
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Microwave properties of integrated film in compaarison with bulk ferroelectric and paraelectric
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Effect of electrodes on GHz ZnO thin film bulk-acoustic-wave resonator
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Polarization correlation and pyroelectric properties of $Pb(Zr,Ti)O_3$ and La doped $Pb(Zr,Ti)O_3$ multilayer thin films
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A new IR nonlinear optical material $CsGeCl_3$
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Ferroelectric and pyroelectric properties of sol-gel derived barium strontium titanate thin films
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Pyroelectric linear array based on PCLT/P(VDF/TrFE) nanocomposite
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J. Zhu, X. Lu, and Y. Wang

The influence of the surface on PZT thing film ferroelectric properties: A lattice model approach
L. Baudry and J. Tournier

The effects of fatigue of the ferroelectric thin film on the device characteristics of metal-ferroelectric-semiconductor FET
K.P. Lee, S.J. Kang, and Y.S. Yoon

Ab initio cluster and point-multipole calculations of electric field gradients in the lithium niobate crystal
M.G. Shelyapina, V.S. Kasperovich, E.V. Charnaya, and B.F. Schegolev

Polarization dependence of piezoelectric properties of polycrystalline ferroelectrics: Ceramics and thin films
A.V. Turik and V.Yu. Topolov

Microscopic theory of glassy state in electric dipole glasses like KCl:OH. Statistical and dynamical behavior
R.V. Saburova and G. Busiello

Piezoelectric 3-3 composites for hydrophones: Modeling and materials selection
C.R. Bowen, R. Stevens, A. Perry, and S. Mahon

Two-component model of hydrogen-bonded ferroelectrics and biomolecular chains
V.S. Bystrov

Elastic interaction between 90˚ domain walls and misfit dislocations in epitaxial ferroelectric thin films
A.Yu. Emelyanov and N.A. Pertsev

Percolation with constraints in the solid solution of incipient ferroelectrics: $KTaO_3$:Li
S.A. Prosandeev, V.S. Vikhnin, and S. Kapphan

INTEGRATION

Oxidation of TiAlN and TaSiN barriers characterized by XRD, AES and TEM
Tito Ayguavives, Sungjin Kim, and Angus I. Kingon

Adaptive-learning neuron circuit using ferroelectric gate FETS
S.M. Yoon, H. Ishiwara, and E. Tokumitsu

Forming gas annealing effects on the microsturcture and ferroelectricity of $SrBi_2Ta_2O_9$ thin films prepared by metalorganic decomposition
Tao Yu, Dong-Sheng Wang, Di Wu, Ai-Dong Li, Xin-Hua Zhu, An Hu, Zhi-Guo Liu, and Nai-Ben Ming

Pt electrode integration study on MOCVD $SrBi_2Ta_2O_9$ films
Kaushal K. Singh, Prabhakar Bandaru, Martin Amberger, Christof Kurthen, Talex Sajoto, V. Siva, and Jun Zhao

Degradation mechanisms of $SrBi_2Ta_2O_9$ ferroelectric thin film capacitors during forming gas annealing
W. Hartner, P. Bosk, G. Schindler, C. Dehm. C. Mazuré,

ISIF 2000 PAPERS

H. Schroeder, and R. Waser

A novel diffusion barrier using oxygen stopping layer for high density 16 Mb FRAM
Yoon J. Song, H.H. Kim, S.Y. Lee, D.J. Jung, B.J. Koo, N.W. Jang, C.J. Kim, K.M. Lee, S.O. Park, and Kinam Kim

Study on simple stacked electrode structure for high density ferroelectric memory devices
Hyun-Jung Woo, Dong-Yeon Park, Dong-Su Lee, Seung-Hyun Kim, Jowoong Ha, Cheol Seong Hwang, and Euijoon Yoon

Effects of Ti/Ir hybrid top electrodes of PZT capacitors on hydrogen related degradation
J. Kim, J.M. Koo, T.H. Kim, I. Bang, and J.G. Lee

Inter-metal dielectric process and hydrogen degradation in integrated $SrBi_2Ta_2O_9$ based ferroelectric memory
S.K. Hong

The electrical properties of strained $(Ba_{0.5},Sr_{0.5})TiO_3$ in MFIS structures
Jaichan Lee

Etch characteristic of iridium thin films in fabrication of ferroelectric capacitors
Chee Won Chung, Chang Jung Kim, and Ilsub Chung

Effect of contact area and perimeter on ferroelectric properties and the modeling
S.S. Lee, E.Y. Kang, J.Y. Sung, J.W. Kim, C.H. Chung, Y.M. Kang, B. Yang, and N.S. Kang

Etching high k and ferroelectric capacitors
Jay Hwang, Chris Ying, Jaklyn Jin, and Steve Mak

Diffusion barrier structures for the integration of CVD-$(Ba,Sr)TiO_3$ capacitors using Ru electrodes
T. Kuroiwa, T. Shibano, Y. Yoneda, M. Tarutani, T. Takenaga, T. Sato, and T. Oomuri

HIGH FREQUENCY DEVICES

Microwave tunable filter employed with ferroelectric films at high microwave power
A. Kozyrev, A. Ivanov, T. Samoilova, O. Soldatenkov, D. Ginley, and T. Rivkin

A mechanism of microwave dielectric loss in ferroelectric thin films
A. Tagantsev

High frequency properties of barium strontium titanate thin films on Pt/Si
G.T. Stauf, J.F. Roeder, A. Tombak, A. Mortazawi, T. Ayguavives, J.-P. Maria, and A.I. Kingon

Effects of annealing on electronic properties of epitaxial BST thin films
W. Lin, J. Zheng, H. Huang, J.J. Schmitt, A.T. Hunt, R.R. Romanofsky, F.W. Van Keuls, and F.A. Miranda

Preparation and investigation of microwave varactors based on strontium titanate and barium strontium titanate thin films

E.K. Hollmann, S.V. Razumov, V.E. Loginov, V.I. Goldrin, A.V. Tumarkin, A.M. Prudan, A.V. Zemtsov, and M.M. Gaidukov

Life cycle testing of thin film $Ba_xSsr_{1-x}TiO_3$ in a tunable microwave device
F.A. Miranda, F.W. Van Keuls, R.R. Romanofsky, C.h. Mueller, and J.D. Warner

Epitaxial growth and characterization of $(Ba,Sr)TiO_3$ thin films
C.L. Chen, J. Shen, Z. Zhang, W.K. Chu, C.W. Chu, H.J. Gao, S.J. Pennycook, F.A. Miranda, and F.W. Van Keuls

MOCVD $Ba_{1-x}Sr_xTiO_3$ (BST) thin films for high frequency tunable devices
P.K. Baumann, S.K. Streiffer, J. Im, O. Auciello, D.Y. Kaufman, J. Giumarra, and R. Erck

Composition control of magnetron sputter deposited BST thin films for voltage tunable devices
Jaemo I, O. Auciello, P.K. Baumann, S.K. Streiffer, C.Y. Kaufman, and A.R. Krauss

Microwave properties of ferroelectric film planar varactors
A. Kozyrev, V. Keis, A. Ivanov, O. Soldatenkov, v. Loginov, A. Taricin, and J. Graul

Higher dielectric tunability of $Ba_{1-x}Sr_xTiO_3$ thin films by compositional heterogeneity of Ba/Sr ratio in micro-region
Yongping Ding and Zhongyan Meng

Thin films functional modules
M. Klee, P. Löbl, R. Kiewitt, W. Brand, and P. Lok

Study of physical properties of some systems of seignettomagnetic solid solutions with the perovskite type structure
V.V. Gagulin, S.K. Korchagina, Yu.A. Shevchuk, and V.V. Ivanova

ISIF 2000 PAPERS

Heat effect as a cause of enhancement of microwave nonlinearity of planar $SrTiO_3$ capacitors on sapphire substrate at T = 78 K
T. Samilova and A. Astafiev

FIELD EFFECT DEVICES

Ferroelectric properties of $YMnO_3$ thin films prepared by chemical solution deposition
C.I. Cheon, K.Y. Yun, J.S. Kim, and J.H. Kim

Electrical properties of metal-ferroelectric-insulator-semiconductor-FET using $SrBi_2Ta_2O_9$ film prepared at low temperature by pulsed laser deposition
H. Sugiyama, K.Kodama, T. Nakaiso, M. Noda, and M. Okuyama

Chemical processing and properties of $Sr_2(Ta,Nb)_2O_7$ thin films
K. Kato

Characteristics of ferroelecttric $YMnO_3$ thin films for MFISFET by MOCVD
Kyu-Jeong Choi Woong-Chul Shin, and Soon-Gil Yoon

Fabrication and characterization of MFISFET using Al_2O_3 insulating layer for nonvolatile memory
Chang Ho Shin, Seon Yong Cha, Hee Chul Lee, Won-Jae Lee, and Byoung-Gon Yu

Dielectric constant measurement of several high-*k* candidates for gate oxides
J.H. Haeni, D.G. Schlom, F. Lichtenberg, and A.G. Petrosyan

On the possibility of using ferroelectric films deposited on silicon in memory devices
A.A. Grekov, S.V. Tolstousov, and E.N. Myasnikov

Characteristics of Pt/SBT/ZrO_2/Si structure for metal ferroelectric insulator semiconductor field effect transistor applications
J.D. Park and T.S. Oh

Low and infralow frequencies dielectric response of multicomponent PZT-based system
Liu Xiaohua, J. Yin, L. Wang, J. Li, X.H. Zhu, K.J. Chen, and Z.G. Liu

Buffer layer dependence of memory effects for $SrBi_2Ta_2O_9$ memory capacitors on Si
J-P. Han, X. Guo, T.P. Ma, A. Ils, M. Cantoni, J-M. Sallese, and P. Fazan

The prototype MFIS structure using strained $(Ba_{0.5},Sr_{0.5})TiO_3$ thin films as ferroelectric
Jaichan Lee

Electrical characteristics of Pt-SBT-poly silicon (Mfip) capacitors with yttrium oxide as the buffer layer
T.S. Kalkur and John Lindsey

DRAM

Electrical behavior of $Mg_xSrTi_{1-x}O_3$ ceramics
A.R. Ferreira, J.M. Perdigao, C. de Francisco, and J. Ignacio de la Torre

DC field induced antiferroelectric phase transition in bulk, single crystal strontioum titanate
S. Gevorgian, A. Eriksson, P. Petrov, P. Linner, G. Lövestam, and E.Wikborg

Universal dielectric response and complex impedance spectroscopy in $(Ba,Sr)TiO_3$ thin films
S. Saha and S.B. Krupanidhi

The study of high dielectric $(Ba,Sr)TiO_3$ thin films deposited by RF magnetron so-sputtering
C.C. Jaing, C.H. Lai, H.L. Kao, and J.S. Chen

Chemical vapor deposition of (Ti,Al)N diffusion barrier layer for high dielectric and ferroelectric capacitors
J. Song, J. Park, C.S. Hwang, D.Y. Yang, Y.K. Han, and C.J. Hwang

AC conductivity and oxygen vacancy mobility and studies in pulsed laser ablated $(Ba,Sr)TiO_3$ thin films
S. Saha and S.B. Krupanidhi

High temperature conductivity behavior of doped $SrTiO_3$ thin films
Ch. Ohly, S. Hoffmann, K. Szot, and R. Waser

On leakage current models applied to thin films
Herbert Schroeder

Structural and dielectric properties of $BaTiO_3/SrTiO_3$ -multilayers deposited by PLD
G. Köbernik, W. Hässler, and F. Weiss

The properties of oriented $(Ba,Sr)TiO_3$ thin films
Wen Ding and Zhongyan Meng

The resistance degradation of $(Ba_{0.5}Sr_{0.5})TiO_3$ thin films
Feng Yan □

PUBLICATIONS

New volumes from MRS …

POLYCRYSTALLINE METAL AND MAGNETIC THIN FILMS

Just published by the Materials Research Society (MRS), *Polycrystalline metal and magnetic thin films* documents symposium reports from the 1999 MRS Spring Meeting in San Francisco, California, and contains 49 papers, 348 pp.

The unprecedented growth in the semiconductor, electronics, and storage industries is the result of continued miniaturization of circuit devices, increases in chip functionality, and increased storage capacity and performance, along with a decrease in per-function cost. Hardware shrinkage has taken place both laterally and vertically, leading to similar decreases in the dimensions of interconnection wires, contact metallization, and magnetic storage footprints. The increasingly important role of surfaces, interfaces, defects, and impurities has raised serious materials questions about how to control the properties of polycrystalline thin films used in applications requiring tight performance tolerances. This is equally true as the dimensions of these films shrink to levels where 100 or fewer atomic layers are routinely being used to achieve critical materials properties. The understanding of polycrystalline film structures during growth, and the evolution of various film properties with time and temperature, is critical to the successful design and development of smaller devices. This volume highlights the direction taken to understand and control the properties of polycrystalline materials. Topics include magnetic thin films, thin-film microstructure, texture and stress, copper microstructure, nanocrystalline magnetic thin films, and thin-film permanent magnets.

Edited by D.E. Laughlin (Carnegie Mellon University), K.P. Rodbell (IBM T.J. Watson Research Center), O. Thomas (Université Aix-Marseille), and B. Zhang (MMC Technology), *Polycrystalline metal and magnetic thin films* [ISBN: 1-55899-469-60] is Volume 562 in the MRS Symposium Proceedings Series and is available in hardcover or microfiche for $59.00 (MRS members), $69.00 (U.S. list), and $76.00 (non-U.S. list).

AMORPHOUS AND HETEROGENEOUS SILICON THIN FILMS: FUNDAMENTALS TO DEVICES

Applications requiring large-area semiconductor coverage rely increasingly on amorphous and heterogeneous silicon materials because they can be deposited at low cost on a variety of substrates. This new volume from MRS covers the range from fundamental research to the device applications of these materials. A special session on medium-range order is featured and confirms the belief that ordering correlates with the electronic quality of a-Si:H films. Important new experimental observations on metastable effects in a-Si:H are also reported, as are new devices and processing strategies. Topics include growth and properties, high-rate deposition, recrystallization, amorphization and porous silicon, ordering and hydrogen, metastability, defects, band tails and transport, heterogeneous materials and devices, thin-film transistors and displays, solar cells, detectors, imagers, and other devices.

Edited by H.M. Branz (National Renewable Energy Laboratory), R.W. Collins (The Pennsylvania State University), H. Okamoto (Osaka University), S. Guha (United Solar Systems Corp.), and R. Schropp (Utrecht University), *Amorphous and heterogeneous silicon thin films: Fundamentals to devices,* [ISBN: 1-55899-464-5] documents symposium proceedings from the 1999 MRS Spring Meeting in San Francisco, California, and contains 135 papers, 888 pages. Volume 557 in the MRS Symposium Proceedings Series, it is available in hardcover for $65.00 (MRS members), $77.00 (U.S. list), and $85.00 (non-U.S. list).

More volumes …

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LIQUID CRYSTAL MATERIALS AND DEVICES
QUASICRYSTALS
ORGANIC NONLINEAR OPTICAL MATERIALS AND DEVICES
MATERIALS RELIABILITY IN MICROELECTRONICS IX

Contact: info@mrs.org www.mrs.org

UPCOMING MEETINGS

SPIE's 2000 Symposium and Education Program on Microelectronic Manufacturing 18–19 September 2000 Santa Clara Marriott, Santa Clara, California, USA

The symposium presents a stimulating program covering challenges in process integration and device technology as well as process control and diagnostics. It investigates the cutting edge manufacturing technologies impacting the current and future production of microelectronics. The challenges range from inception of a technology to the cost-effective production to state-of-the-art microelectronic devices. A complimentary education program provides in-depth training opportunites by experts in semiconductor manufacturing. The symposium has ample "connectivity" opportunity for the researchers aand engineers in academia, government, and the private sector. In addition to benefits gained from technical exchanges, the "connectivity" determines the participants' ability to manufacture cost-effective, reliable products and deliver them on time.

Topics of Short Courses

- Semiconductor characterization, reliability, and failure analysis
- Vertical scaling for deep submicron devices: Dielectrics, dopants, and contacts
- MOEMS/MEMS: Technology and applications
- Dry etching in microelectronic manufacturing
- Practical process designs for microlithography
- MOS gate dielectrics: Process, technology, and reliability
- Chip reliability
- Copper interconnect technology
- Deep sub-micron process integration and characterization
- Extending semiconductor lithography resolution using image process integration
- RF MEMS and reconfigurable antennas for wireless communication
- Polysilicon surface micromachine technology and devices
- Multilevel interconnection technology
- Submicron device physics and technology
- Integrated circuit fabrication technology and yield control

Continuing Education Program

Diagnostics, Yield, and Reliability

- Semiconductor characterization, reliability, and failure analysis
- MOS gate dielectrics: Process, technology, and reliability
- Chip reliability
- Submicron device physics and technology

Device and Process Technology

- Vertical scaling for deep submicron devices: Dielectrics, dopants, and contacts
- Dry etching in microelectronic manufacturing
- Deep sub-micron process: Integration and characterization
- Multilevel interconnection technology
- Copper interconnect technology
- Integrated circuit fabrication technology and yield control

UPCOMING MEETINGS

Multilithography and Patterning
- Practical process design for microlithography
- Extending semiconductor lithography resolution using image process integration

Micromachining and Microfabrication
- Polysilicon surface micromachine technology and devices
- MOEMS/MEMS technology and applications
- RF MEMS and reconfigurable antennas for wireless communications

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2000 Fall Materials Research Society (MRS) Meeting
27 November–1 December 2000
Boston, Massachusetts, USA

The 200 Fall MRS Meeting will highlight recent and significant advances in the understanding, processing, and synthesis of materials. Over 40 technical symposia will cover a wide range of topics in materials science, including nanoscale materials, device and functional materials, thin films, defects and interfaces, novel processing methods, and polymeric materials. This meeting will also include a special cluster of symposia dedicated to biomedical materials.

New symposia will be offered in many exciting areas such as nanoscale materials and fabrication, microphotonics, spintronics, novel semiconductor materials, glassy and quasicrystalline alloys, applied magnetic field effects in processing, thermal barrier coatings, ultrafast optical phenomena, irradiation effects, interfaces, and the limits of the strength of materials. Popular ongoing series of symposia will continue in nitride semiconductors, thin-film mechanicl properties, high-temperature intermetallics, ion beam synthesis, dynamics in confined systems, concrete, catalytic materials, materials science of MEMS, ferroelectrics, and organic electronics.

Symposia on computer modeling and calculations in materials science will provide a forum for interaction between theorists and experimentalists. The biomaterials symposia will examine neurological, cardiovascular, orthopedic, and dental biomaterials and biomaterials for drug delivery. Strong interaction among the symposia will highlight the interdisciplinary nature of materials science.

Tutorial sessions in selected areas will provide introductions to new fields. There wil be an exhibition of products and services of interest to the materials community, and the popular Symposium X series will feature topics on the fore-front of materials science.

Symposium CC: Ferroelectric Thin Films IX
This symposium will provide a wide range of topics encompassing basic academic research to applied integration issues. These topics will cover fundamental materials properties studies, new growth methods, device and materials integration research, and developments in designing and growing new materials, all involving epitaxial, polycrystal-line, and nanocrystalline ferroelectric thin films. Ferroelectric materials span a broad range of properties, and this symposium will cover high dielectric constant materials for DRAM and tunable RF circuits, ferroelectric switching for nonvolatile memory devices, low-loss electrooptical thin films, high-response pyroelectric materials, piezoelectric

UPCOMING MEETINGS

properties for micromachines , and basic materials research on all of the compounds that make these applications possible. Many other rapidly developing research areas, as well as memory technologies, will also be represented.

Contributions are solicited in, but not limited to, the following areas:

- DRAM materials and devices
- Fe RAM materials and devices
- Advances in ferroelectric and electrode deposition
- New materials and devices
- Electrode effects
- Issues of integration into semiconductor processess such as H_2 degradation
- Ferroelectric and electrode etch processes

Symposium Organizers

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UPCOMING MEETINGS

13th International Symposium on Integrated Ferroelectrics (ISIF 2001)
11–14 March 2001
Colorado Springs, Colorado, USA

Recent progress in research on ferroelectric thin films and the resultant technological applications are signs of a bright future for research and new applications of the technology. The growing maturity of ferroelectric applications is an indication of the high activity in research and commercialization.

The work on high permittivity thin films suggests that these materials may play a fundamental role in a new generation of DRAMs. The field of ferroelectric/piezoelectric materials is experiencing considerable growth due to the potential applications in MEMS technologies. Pyroelectric sensors, integrated high-frequency devices, electrooptical components, nanotechnology and the exploitation of nano-size effects will all be topics addresses at this symposium.

Topics

- Device integration issues
- Testing and characterization
- DRAMs and materials
- FeRAMs and materials
- Modeling and theory
- High frequency devices
- Pyroelectric/IR and optical applications
- Piezoelectric and MEMS applications
- Nonvolatile memory applications
- Nano-size effects
- Circuits and devices
- Field effect devices
- Novel characterization
- Ferroelectrics for space applications
- Graded ferro devices
- Integrated sensors

Special Topic for 2001

- FeRAM-based smart cards/tags and applications

Deadline for Abstracts

31 October 2000

Contact

Kerry Baugh, Symposium Coordinator, University of Colorado at Colorado Springs
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UPCOMING MEETINGS

2001 Spring Materials Research Society (MRS) Meeting
16–20 April 2001
San Francisco, California, USA

This meeting will include 33 symposia that highlight new advances in the understanding, synthesis, and application of materials in fields ranging from advanced integrated circuits to biomaterials.

All abstracts are to be submitted to MRS headquarters. Abstracts submitted by fax or mail must be received at MRS by 18 October 2000. Due to the ease and efficiency of Web submissions, the deadline for abstracts sent via the MRS Website will be extended until 1 November.

More than 97 percent of authors submit their abstracts by using the MRS Website. Web submittal provides step-by-step instructions, the extended deadline of 1 November, and immediate confirmation of receipt. The abstract submission Website will be activated 1 October. Templates and complete submission instructions may be found on the MRS Website at **www.mrs.org/meetings/spring2001/**

Thin Films and Surface Phenomena Symposia

- Mechanisms of surface and microstructure evolution in deposited films and film structures
- Dislocations and deformation mechanisms in thin films and small structures
- Femtosecond materials science and technology
- Morphology and dynamics of crystal surfaces in molecular and colloid systems
- Fundamental studies of corrosion and oxidation

Contact

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" Tunable Microwave Devices and Circuits"

This special focused session will be held at the Asia Pacific Microwave Conference (APMC 2000) from 3–6 December 2000 in Sydney, Australia.

For more information please contact

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UPCOMING MEETINGS

8th International Conference on Ferroelectric Liquid Crystals (FLC 2001)
5–11 August 2001
Georgetown University, Washington, D.C. USA

The conference is the eighth in a series of biennial international meetings. The first conference was held in Arcachon (France) in 1987, followed by Gothenborg (Sweden) 1989, Boulder (USA) 1991, Tokyo (Japan) 1993, Cambridge (UK) 1995, Brest (France) 1997, and Darmstadt (Germany) 1999.

The main aim is to bring together scientists, engineers, and students active in the field of ferroelectric liquid crystals and related topics to present and discuss their recent and advanced developments in the area.

The program will consist of invited lectures, oral and written contributions. Tutorials, demonstrations, and posters will be part of the conference.

The proceedings will be published in special editions of ***Ferroelectrics***.

Topics

- Synthesis and design of new materials
- Properties of new mixtures for application
- Banana-shaped and achiral switchable systems
- Ferro-, ferri-, antiferroelectric and TGB phases
- PSFLCs, PDFLCs and FLC networks
- Ferroelectric and pyroelectric polymers; ferroelectric and chiral bipolymers
- Surface interactions
- Modeling of FLCs
- Linear, nonlinear, and electrooptical properties
- Device technology: Addressing, switching, alignment
- Nondisplay applications: Switching, data processing, telecommunication
- Display application

Contact

FLC 2001, c/o Betty J. Lamb, GEO-CENTERS, Inc.
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UPCOMING MEETINGS

10th International Meeting on Ferroelectricity (IMF-10)
3–7 September 2001
Madrid, Spain

This conference will be the 10th in a series of meetings held regularly every four years. It will cover a broad range of topics about ferroelectric materials, ferroelectric transitions and related systems including experimental work on physical, structural, dielectric, thermal, acoustic, electromechanical, and optical properties, as well as on theory and applications.

Topics

Materials

- New ferroelectric and related materials
- Thin films
- Relaxor ferroelectrics
- Polymers and liquid crystals
- Ferroelectric ceramics processing

Properties

- Nonlinear properties
- High-pressure effects
- Microwave and dielectric properties
- Raman, Brillouin, and IR spectroscopies
- NMR, ESR, and NQR studies

Theory

- Domains and domain structures
- Defects and imperfections
- Structure and crystal growth
- Advances in theory
- Phase transitions and critical phenomena
- Incommensurate transitions
- Quantum effects
- Computer simulations
- Disorder symptoms

Applications

- Piezoelectricity
- Pyroelectricity
- Ferroelasticity
- Sensors, actuators, and transducers
- Novel applications

Contact

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CALENDAR OF EVENTS 2000

Aug 27-30	•	5th European Conference on the Application of Polar Dielectrics (ECAPD-5), Jurmala, Latvia (see *Ferroelectricity Newsletter*, Vol. 7, No. 3, p. 17)
Sep 3-6	•	Electroceramics VII, Portoroz, Slovenia (see *Ferroelectricity Newsletter*, Vol. 7, No. 3, p. 18)
Sep 11-14	•	3rd (8) International Seminar on Ferroelastics Physics (ISFP-3(8), Voronezh, Russia (see *Ferroelectricity Newsletter*, Vol. 8, No. 2, p. 16)
Sep 18-19	•	Microelectronic Manufacturing, Santa Clara, California, USA (see p. 29)
Sep 25-28	•	Materials Week, International Congress on Advanced Materials, Their Processes and Applications, Munich, Germany (see *Ferroelectricity Newsletter*, Vol. 8, No. 2, p. 17)
Nov 27-Dec 1	•	MRS 2000 Fall Meeting, Boston, Massachusetts, USA (see p. 30)
Dec 3-6	•	Session on"Tunable Microwave Devices and Circuits," Asia Pacific Microwave Conference (APMC 2000), Sydney, Australia. Contact: gsubrama@engr.udayton.edu
Dec 12-15	•	3rd Asian Meeting on Ferroelectrics (AMF-3), Hong Kong, China (see *Ferroelectricity Newsletter*, Vol. 7, No. 3, p. 19)

2001

Mar 5-8	•	"Active Materials: Behavior and Mechanics (ss08)," Part of SPIE's 8th International Symposium on Smart Structures and Materials, Newport Beach, California, USA Contact: lupascu@ceramics.tu-darmstadt.de
Mar 11-14	•	13th International Sympoium on Integrated Ferroelectrics (ISIF 2001), Colorado Springs, Colorado, USA (see p. 32)
Apr 16-20	•	MRS 2001 Spring Meeting, San Francisco, California, USA (see p. 33)
Aug 5-11	•	8th International Conference on Ferroelectric Liquid Crystals (FLC 2001), Washington, D.C., USA (see p. 34)
Sep 3-7	•	10th International Meeting on Ferroelectricity (IMF-10), Madrid, Spain (see p. 35)

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